



UNIVERSITY
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Power Management Solutions for ULP SoCs

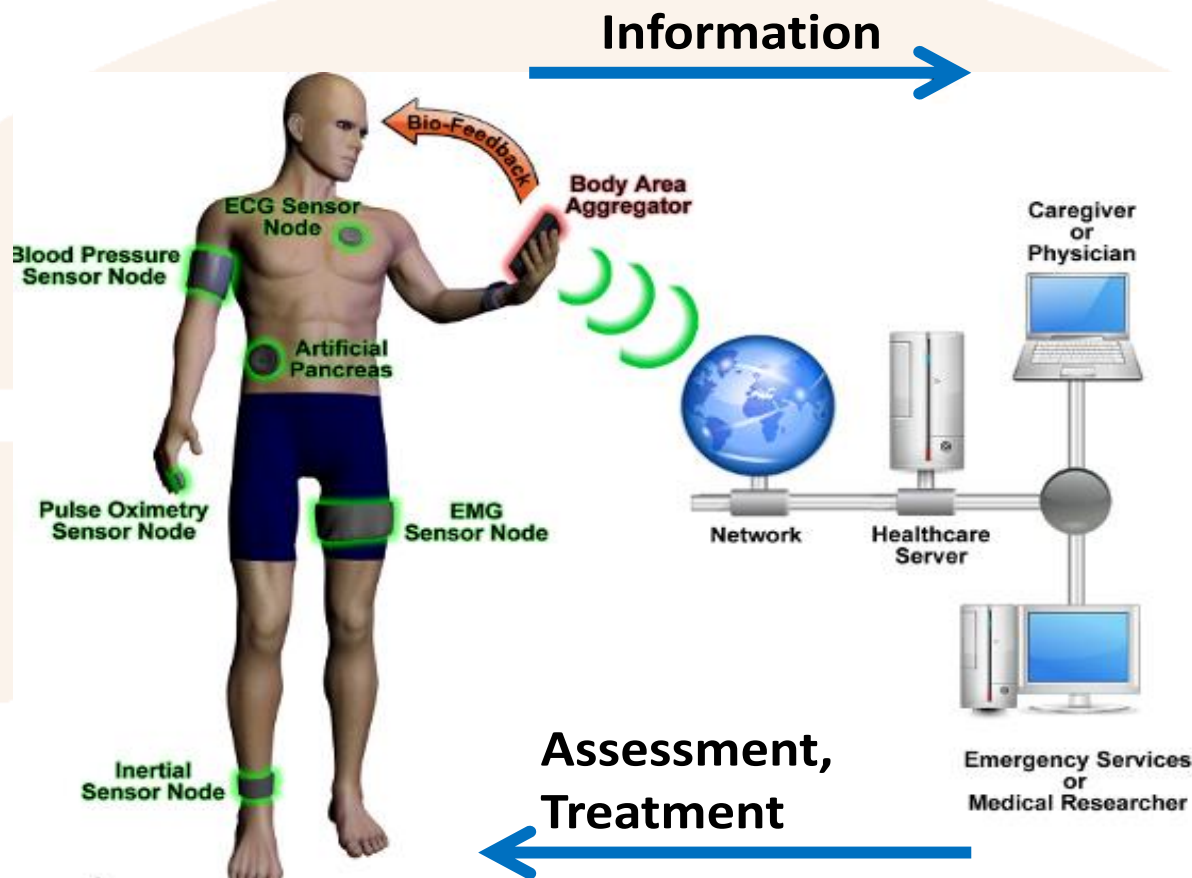
Deliberate Practice -I

Seyi and Aatmesh

1st May 2013

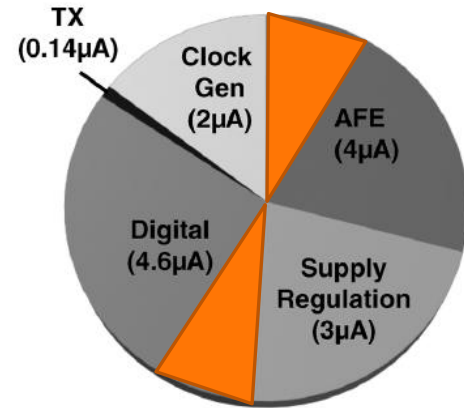
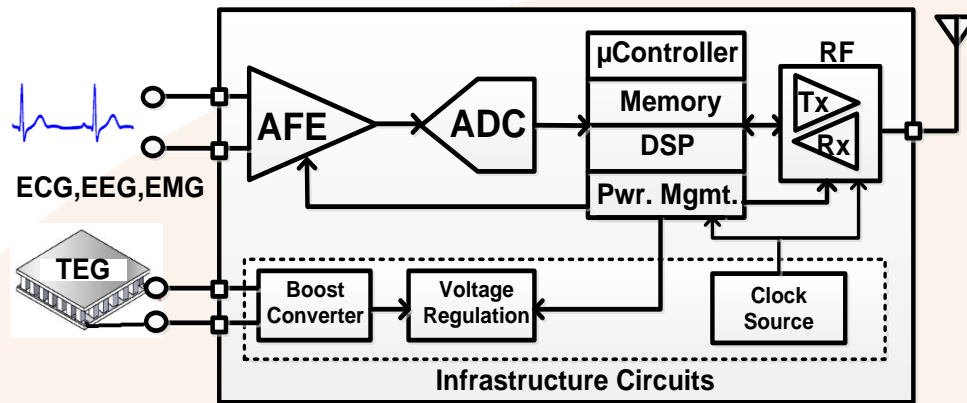
**ROBUST
LOW
POWER
VLSI**

Ultra Low Power SoCs (e.g. BSN)



- BSNs promise to change the way we live
- Need higher life-time for ubiquitous deployment
- **Energy harvesting and Power Management is critical**

Power Distribution in BSN

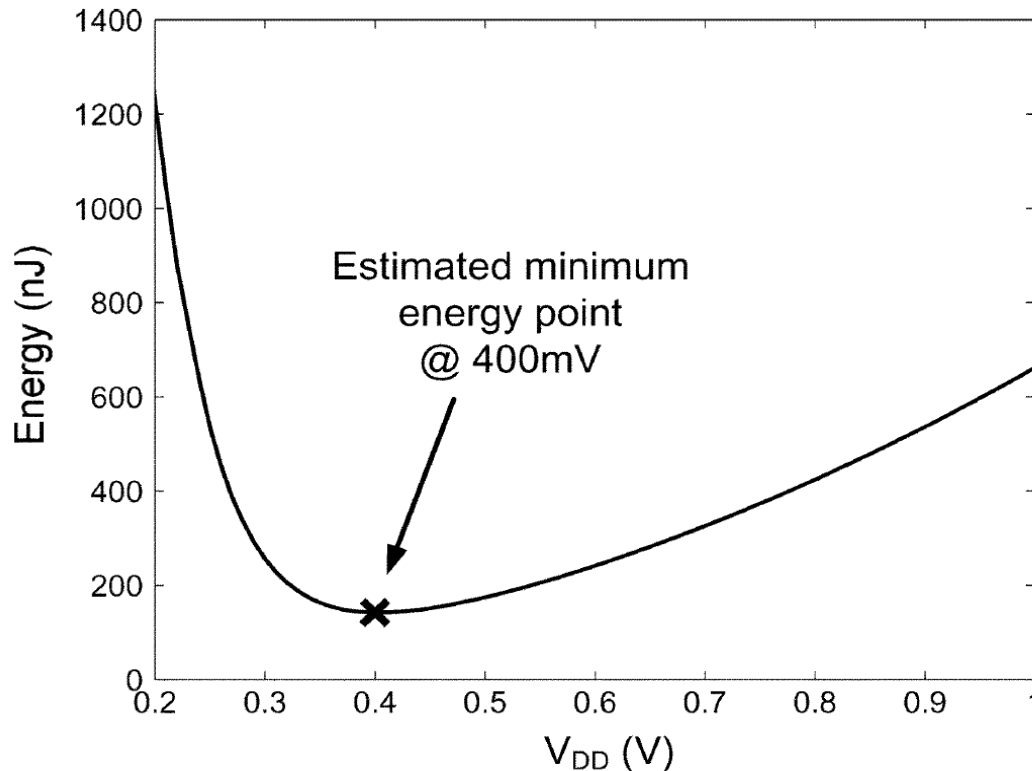


19 μ W out of 50 μ W from TEG

Y. Zhang, et al, "A Batteryless 19 μ W.... ", JSSC, Jan. 2013.

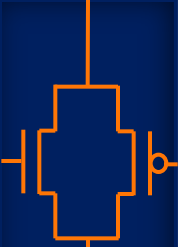
- Efficient energy-harvesting (E-harvesting)
 - To increase the amount of harvested energy
- Efficient multiple regulated output voltages
 - To minimize the loss in voltage regulation
- **Power Management critical to BSN lifetime**

Power Supply Needs



A. Wang, et al, "A 180-mV Subthreshold ..."
JSSC, Jan. 2005

- Optimal energy point exists for each blocks such as CPU, Analog, RF etc.
- Multiple regulated output voltages is needed.



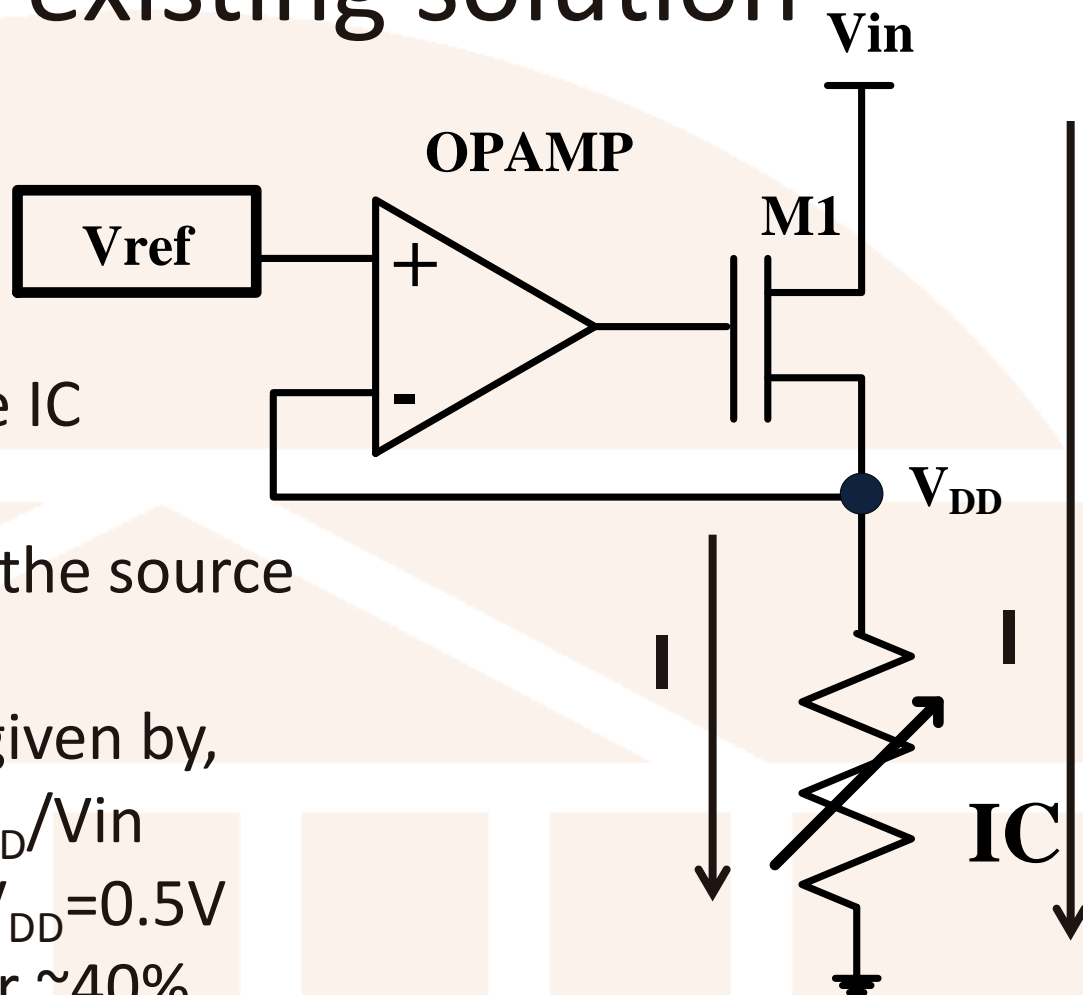
Power Supply needs for BSN

- Optimal voltages exists for each Block in a BSN, which needs multiple supplies for BSN
- Since BSNs operate in energy constrained environment each supply should be efficient
- BSNs need efficient energy harvesting to further extend the lifetime

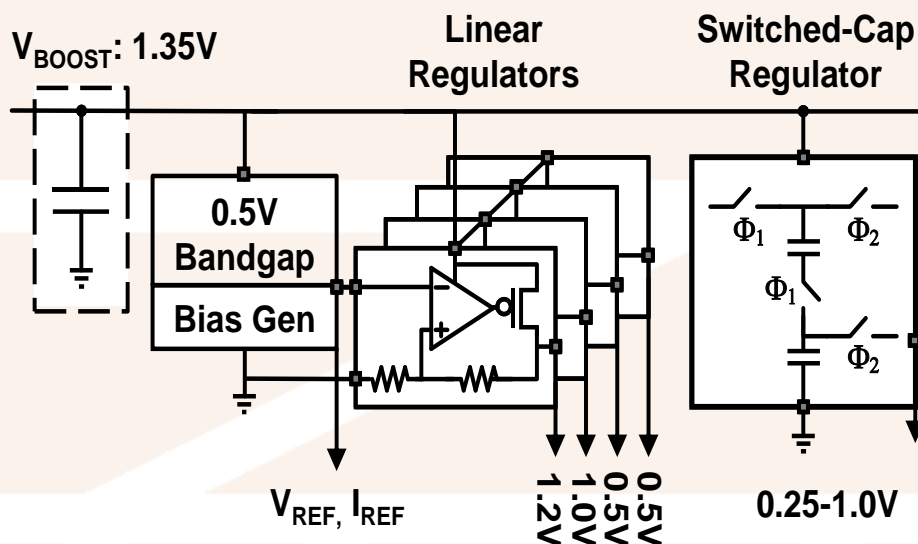
Limitation of existing solution

LDO

- Input power to the IC
 - $V_{DD} * I$
- Power taken from the source
 - $V_{in} * I$
- Ideal Efficiency is given by,
 - $V_{DD} * I / V_{in} * I = V_{DD} / V_{in}$
- Ex, $V_{in} = 1.2V$ and $V_{DD} = 0.5V$
- Efficiency is 0.41 or ~40%.
- **Almost 60% of power is lost in regulation**



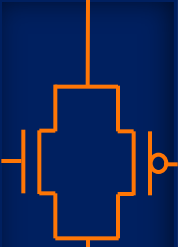
State of the art BSN SoC Power Management



Voltage Domain	Blocks Powered
1.2V	Pads, AFE
1.0V	TX LO
0.5V	TX PA
0.5V	DPM, MEM, Accels
SC Reg. (0.25-1.0V)	Accels for DVS

Y. Zhang, et al, "A Batteryless 19uW....", JSSC, Jan. 2013.

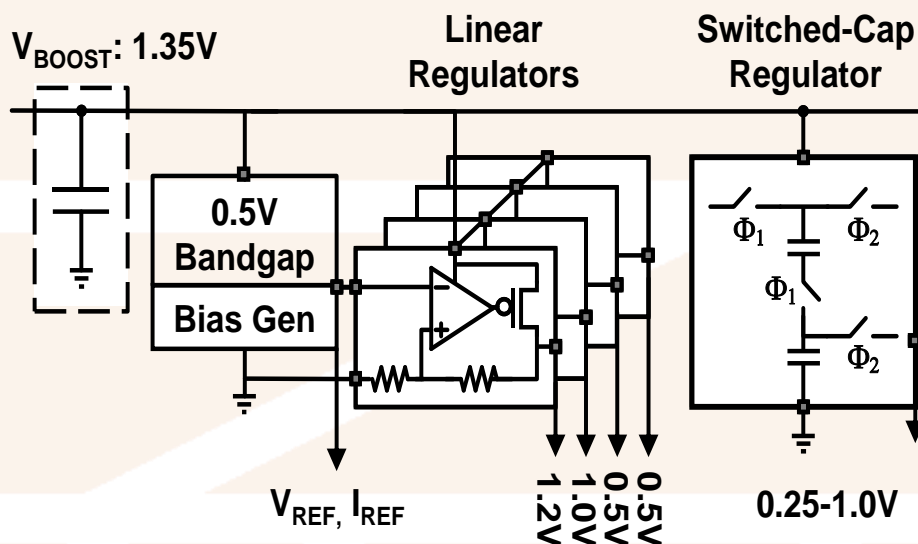
- Boost converter harvests the energy on to a capacitor at 1.35V
- Multiple rails are served by linear regulators
- **63% 23% and 12% energy is lost in voltage regulation.**



Research Questions

- There is a theoretical limit on the efficiency of LDO.
- **What can replace LDOs ??**

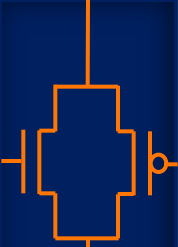
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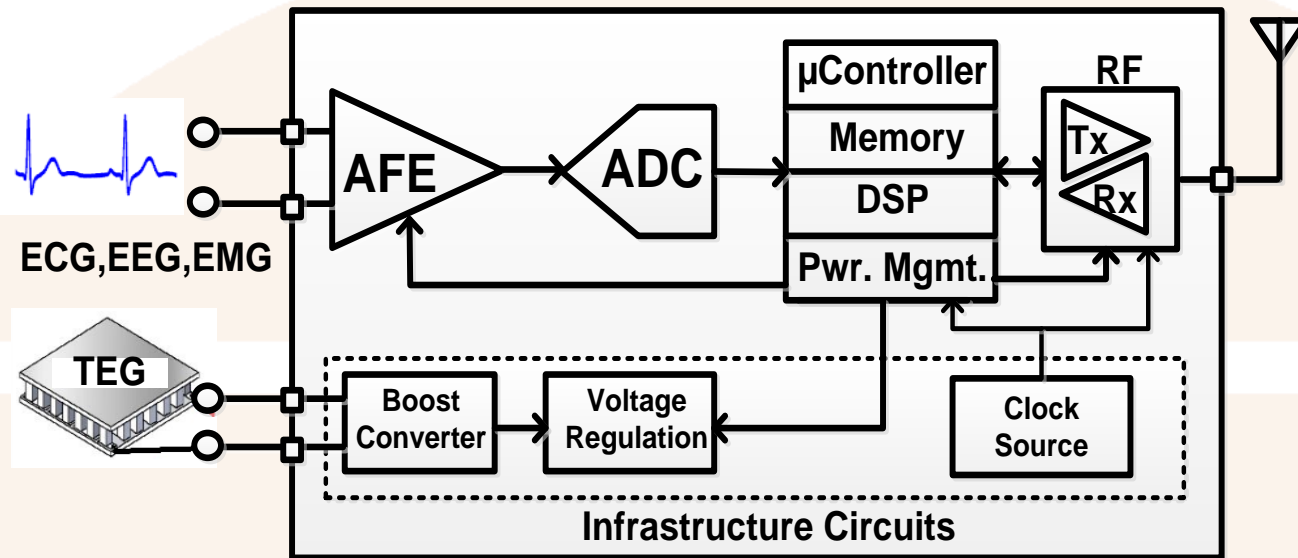
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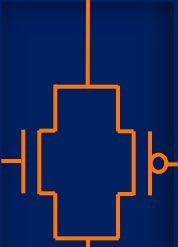
- BSN needs multiple output voltages.
- **How do solutions replacing LDOs can address this problem?**

Energy Harvesting



Y. Zhang, et al, "A Batteryless 19uW....", ISSCC, Feb. 2012.

- State of the art solution is 38% efficient.
- How can we raise this efficiency?



Research Questions

- **How do voltage regulation and energy harvesting solutions integrate together for BSNs?**
- **What additional costs are attributed to the solution?**
- **How will the power of the new solutions be monitored?**
e.g. DPM (Shaksheer et. al.)